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Publications en zoologie, n° 4

Publications in Zoology, No. 4

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Musées nationaux du Canada

National Museums of Canada

1970

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Issued under the authority of
The National Museums of Canada

FAUNA OF SABLE ISLAND AND ITS ZOOGEOGRAPHIC AFFINITIES – A COMPENDIUM

By H. F. Howden
J. E. H. Martin
E. L. Bousfield
D. E. McAllister

Ottawa 1970

Catalogue No. NM95-10/4

Contents

List of Tables

List of Plates

List of Maps

SUMMARY

The faunistic groups discussed for Sable Island, Nova Scotia, include Insecta, Coleoptera (125 species), Odonata (5 species), Orthoptera (1 species), Lepidoptera (Noctuoidea, 23 species); Crustacea, Amphipoda (7 species), Isopoda (5 species); Annelida, Oligochaeta (2 species), Hirudinea (3 species); and Vertebrata, Pisces (3 species). Most of these have not been previously recorded from the Island, and a few are new to Canada.

Collection data and climatic information for the survey periods in 1966 and 1967 are given. Zoogeographic comparisons are made for terrestrial, freshwater, and littoral marine organisms with particular reference to the species of adjacent land areas. The assumption that the Sable Island area and adjacent banks served as refugia during the last Wisconsin glaciation seems reasonable on the basis of the data presented.

RÉSUMÉ

Parmi les groupes fauniques dont il est question dans la partie traitant de l'Île de Sable, en Nouvelle-Écosse, figurent les Insectes: Coléoptères (125 espèces), Odonates (5 espèces), Orthoptères (1 espèce), Lépidoptères (Noctuidés, 23 espèces); les Crustacés: Amphipodes (7 espèces), Isopodes (5 espèces); les Annélides: Oligochètes (2 espèces), Hirudinés (3 espèces); et les Vertébrés: Poissons (3 espèces). La plupart n'avaient pas encore été observés dans l'île, certains sont même nouveaux au Canada.

L'auteur présente des notes sur la capture des spécimens, et expose les conditions atmosphériques qui ont régné au cours des expéditions de 1966 et 1967. Il fait des comparaisons, du point de vue de la zoogéographie, entre les organismes terrestres, les organismes d'eau douce et ceux du littoral marin, en mentionnant tout particulièrement les espèces des zones terrestres adjacentes. En se fondant sur les données exposées, il semble raisonnable de supposer que la zone de l'Île de Sable et des côtes voisines a servi de refuge pendant la dernière période glaciaire du Wisconsin.

THE COLEOPTERA

BY H. F. HOWDEN*

INTRODUCTION

Sable Island is a sandy, crescent-shaped island that lies near the edge of the continental shelf at 43°57′N and 59°55′W, approximately 150 miles east of Halifax, Nova Scotia. The island has been the subject of interest and speculation, not only because of its historical interest, but also with regard to its biological and geological characteristics. Numerours papers have been written about the historical aspects of the island, and lists of the plants, verterbrates, and molluscs have been published (Erskine 1954; Clarke 1968). Despite this, no detailed study of the insect fauna was made until parties from the Entomology Research Institute, the National Museum of Natural History, and the Geological Survey of Canada visited the island in June 1966 and in July and September 1967. The present paper deals with the 126 species of beetles found on the island, their niches, abundance, time of occurence, and their zoogeographic relationships with the Nearctic and Palearctic faunas.

ACKNOWLEDGEMENTS

The Sable Island survey was made possible by the cooperation of numerous groups and individuals, whose assistance is gratefully acknowledged. In 1966 transportation was arranged through the Department of Defence, with Lt. Comdr. D. A. Muncaster, Commanding Officer of Helicopter Utility Squadron 21, Shearwater, N.S., in charge of the operation. In July and September of 1967 Mobil Oil Canada, Limited, furnished transportation and both Mr. A. R. Nielsen, President and General Manager, and Mr. B. E. George, in charge of operations at Halifax, were most helpful. While the survey party was on Sable Island, the members of the Department of Transport assisted in many ways, and we are particularly grateful to Mr. and Mrs. F. Androschuk and Mr. and Mrs. N. Bell.

The following personnel made up the survey parties. June 6-13, 1966 – A. H. Clarke, National Museum of Natural History; J. H. Rick, National Parks Branch, Department of Indian Affairs and Northern Development; H. F. Howden and W.R.M. Mason, Entomology Research Institute. July 1-18, 1967 – W. J. Brown, H. F. Howden, J.E.H. Martin, R. H. Mulvey, and D. M. Wood, Entomology Research Institute; R. J. Mott and J. Terasmae, Geological Survey of Canada, Department of Energy, Mines and Resources. September 11-15, 1967 – E. C. Becker, J.E.H. Martin, and W.R.M. Mason, Entomology Research Institute.

Sable Island climatic data for 1966 and 1967 were compiled with the assistance of Mr. G. Kendall, Meteorological Branch, Department of Transport.

The following persons assisted with the determinations of the Coleoptera for the groups noted: Anthicidae – F. Werner; Aquatic Coleoptera – W. J. Brown;

*Biology Department, Carleton University, Ottawa, and Entomology Research Institute, Canada Department of Agriculture, Ottawa.

Carabidae – H. Goulet, C. Lindroth, R. de Ruette; Chrysomelidae and Curculionidae – W. J. Brown; Elateridae – E. C. Becker; Histeridae – R. Wenzel; Staphylinidae – J. M. Campbell, L. Herman, M. Sanderson, A. Smetana; other Coleoptera – W. J. Brown.

Lists of other groups are credited to those who compiled them.

ACTIVITIES OF MAN ON SABLE ISLAND

In any consideration of the fauna of Sable Island, it is necessary to consider the influence of man with respect to the disturbance of habitats by purposeful and 'chance' introductions of plants and animals. Attempts to settle the island began in the 16th century; Lanctot (1933) has given a very interesting account of the La Roche settlement of 1598, which was not, as popularly supposed, merely the abandonment of prisoners. Even at that time there were wild cattle on the island that had probably been left (according to references cited by Lanctot) in 1539 by the Baron de Leri. The La Roche venture ended in 1603. Subsequently various attempts to stock or settle the island were made by a number of groups. In 1738 Le Mercier is said (Erskine 1954) "to have stocked the island with cattle, and it is presumed that he brought horses from New England at the same time." In 1801, the government of Nova Scotia established lifesaving stations on the island, and at least a few people have been resident since that time. Today the Department of Transport maintains a meteorological station on the island with a staff varying from 11 to 15 persons. There are no other permanent residents.

The introduction of various animals undoubtedly has had its effect on the native fauna. Cattle, pigs, Norway rats, cats, rabbits, dogs, and horses have all been present in numbers at various times during man's residency (Cameron 1965). Today only the horses remain. Other strictly terrestrial mammals, such as mice, are absent.

Plants, purposely introduced, have not fared much better. In 1901 an effort was made to stabilize the blowing sands by planting 81,345 trees and shrubs. A detailed account of this project was given by Saunders (1902), along with a list of the species introduced. Most of these were brought as seedlings from northern France (68,755 evergreens of 25 species, and 12,590 trees and shrubs of 79 species). They were packed in 18 boxes, without soil as far as I can ascertain, and were in transit for six weeks. A smaller shipment of about 2,000 plants, including 1,000 willow cuttings, originated from mainland Canada, the willows, at least, being brought from Brandon, Manitoba. Initially, the plantings appeared to be successful, but salt spray carried by fall and winter gales gradually eliminated the trees. The cause of the damage was not recognized as such at the time. In 1952 Erskine (1954) found one 15-inch shrub of buckthorn (*Rhamnus frangula*), which he suspected was the sole remnant of the 1901 planting. In 1954 Erskine listed 105 vascular plants that he had personally collected on the island and that he considered "native", and another 27 (20 per cent) that he considered "introduced." What portion of the introductions were purposeful remains unknown.

Chance importation of plants and animals undoubtedly has been an important factor, although less important, perhaps, than in the adjacent maritime provinces

of Canada. Lindroth (1957) has developed a very plausable 'ballast theory' to explain the large number of European plants and animals (insects) that are now found in the maritime provinces. In the 17th and 18th centuries ballast consisting of dirt and rubble, which largely originated from France and England, was offloaded onto land because of laws against dumping the ballast into the major harbours. The fact that the flora and fauna of the ballast were often not subject to immersion in salt water accounts, at least in part (according to Lindroth), for the successful establishment of so many of the European species. This theory must be modified, however, when applied to Sable Island. The sandy shores and shoal waters surrounding the island prevent large ships from approaching the shore. At one time small ships could enter one lagoon, but since the early 1700's all supplies have been brought to the island by lighter or surf boats. Under these conditions it is doubtful that ballast was ever offloaded onto the island.

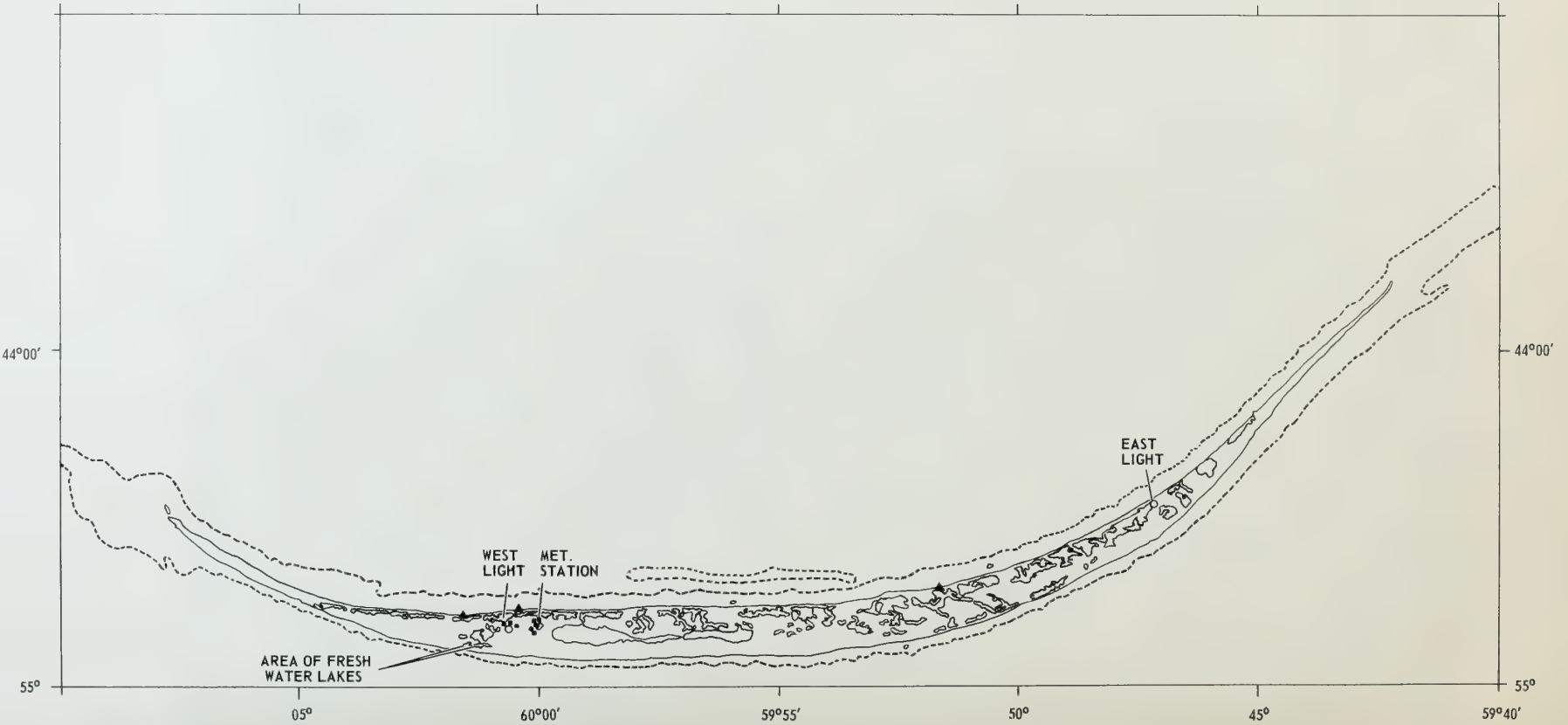
On the other hand, the numerous shipwrecks (*see* chart published by Grosvenor 1965) must be considered a likely source for chance imports. Here, as pointed out to me by J. Rick, one should consider the way ships were wrecked. When ships went aground, they were broken up slowly because of the sandy bottom. This means that any ballast would be thoroughly saturated with salt water, so that seeds or insects reaching the island via the shipwrecks would need to have some tolerance for immersion in salt water. Another source of chance imports was the hay brought at various times from mainland Canada as feed for livestock. This latter source could well be the most important one for the establishment of certain families of insects on the island. The problem of imports will be mentioned again under the discussion.

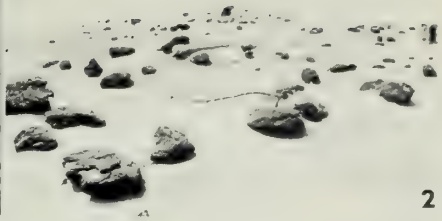
PHYSICAL FEATURES AND CLIMATE

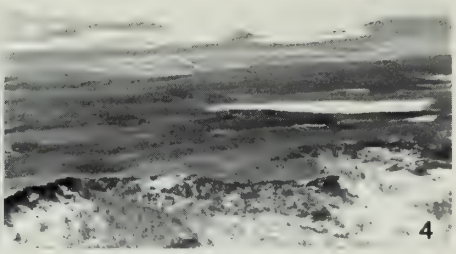
As its name implies, Sable Island is composed entirely of sand. The island extends along an east-west axis (Map 1) for roughly 20 miles, has a maximum width of 1 mile and a maximum elevation of approximately 100 feet. The south beach is wide, with a very gradual slope; the north beach is much narrower and more abrupt. The highest dunes, which are generally along the northern side, attain maximum height near the east end. Between the dunes, where they flank the northern and southern beaches, there are often depressions, frequently filled with water. These lakes are most prevalent near the western end, diminishing in frequency and permanence toward the eastern end. Salinity of the lakes varies depending on exposure; several are essentially fresh water.

The changing topography of the island has been of interest for many years. Any strong wind causes a veritable sandstorm, and the erosion by wave action has been particularly pronounced on the west end of the island. Predictions of the disappearance of the island and estimates of erosion of the west end appear in numerous references. Erskine (1954) listed various estimates: 1633 – estimated size of the island, 40 miles in circumference and much longer than wide (in this case certainly not more than 20 miles long); 1814 – four miles of west end washed away; 1820 – four miles of west end washed away; 1821-1851 – eleven miles of west end washed away; 1881-1883 – three miles of west end washed away; 1930-1939 – three miles of west end washed away.

Map 1 – Sable Island







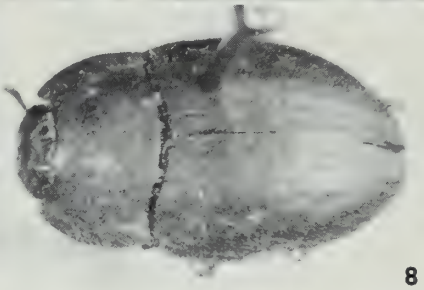


PLATE I

Figs. 1,2. Fossil peat washed up on the south shore near the East Light
3. 'Blow out' along north shore near the West Light
4,5. Freshwater lakes between West Light and meteorological station
6. Collecting along drift line of freshwater lake
7. Vegetation and drift near freshwater lake
8. *Ephalus latimanus*, a flightless tenebrionid beetle

TABLE I

Climatic Data – Sable Island

Months	Maximum Temp.	Minimum Temp.	Total Precipitation	Average hourly velocity of wind	Maximum velocity	Number of gales	Fog
1900	°F	°F	Inches	mph	mph	Days	Days
January	52.5	17.0	5.76	23.7	56	20	5
February	52.0	7.0	3.59	26.5	56	20	3
March	48.5	15.5	6.15	22.2	52	19	8
April	52.5	32.5	5.55	19.4	46	16	6
May	57.8	34.0	3.04	16.2	37.	6	7
June	69.0	40.0	2.84	14.2	27	6	14
July	75.0	49.0	2.25	13.4	32	3	18
August	73.0	51.0	6.16	13.6	40	4	6
September	70.0	47.0	5.66	16.2	49	7	8
October	66.0	37.0	2.31	17.4	51	11	5
November	60.5	27.0	2.94	22.7	46	24	8
December	49.0	20.0	2.94	21.8	52	15	3
Averages	60.48	31.41	4.09	18.9	45	12	7
1901							
January	47.0	5.0	3.24	22.7	58	14	9
February	45.5	19.0	3.21	21.9	45	9	4
March	47.0	19.0	4.04	20.2	56	12	11
April	54.0	34.0	2.36	19.4	60	4	17
May	57.0	34.0	4.97	13.3	34	1	10
June	63.0	44.0	2.38	14.8	36	1	15
July	77.0	53.0	2.90	12.9	36	0	19
August	78.0	60.0	3.36	11.3	34	1	13
September	76.5	48.0	1.65	17.4	42	5	7
October	68.0	41.0	4.52	18.4	48	4	9
November	57.5	30.0	2.10	18.2	62	7	0
December	–	–	–	–	–	–	–
Averages	60.95	35.18	3.17	17.3	46	5	10
1966							
January	45	20	4.88	22.3	64	1.8	4
February	47	3	2.02	19.6	52	8	4
March	47	19	4.11	16.1	38	6	12
April	45	28	0.87	13.9	39	5	13
May	58	34	6.35	14.3	43	5	19
June	60	42	4.96	12.7	32	1	21
July	70	48	6.23	11.1	28	0	26
August	71	49	3.49	11.9	29	0	14
September	70	43	2.69	13.6	36	1	11
October	65	33	4.61	15.5	40	5	12
November	60	28	1.81	15.2	34	2	10
December	55	26	6.64	16.9	40	10	6
Averages	57.5	32.1	4.06	15.2	39.6	5	13
1967							
January	50	13	6.71	16.7	52	10	5
February	51	6	5.83	20.9	58	14	5
March	49	12	3.78	18.8	44	13	7
April	52	25	3.81	17.9	42	5	10
May	53	35	7.11	15.0	42	6	21
June	63	37	2.59	12.1	36	1	18
July	72	51	1.76	10.6	24	0	30
August	76	56	5.23	10.6	24	0	18
September	76	48	2.15	13.1	36	2	3
October	68	37	1.64	14.0	34	2	4
November	63	28	6.13	17.7	46	11	5
December	52	24	3.59	18.6	47	11	1
Averages	60.4	31.0	4.19	15.5	40.4	6	11

TABLE II

Daily climatic data for survey periods

Date	Maximum Temp.	Minimum Temp.	Total Precipitation	Days with some fog
	°F	°F	inches	
June				
6	57.2	45.0	.04	0
7	56.0	45.0	0	1
8	57.8	47.0	.02	1
9	57.8	45.3	0	1
10	50.1	44.1	.51	0
11	53.3	43.0	.70	1
12	52.6	43.2	0	0
	°F	°F		
July				
1	63.6	50.1	0	1
2	57.7	51.0	0	1
3	63.0	53.4	0	1
4	62.3	54.7	.04	1
5	60.8	53.2	.01	1
6	58.9	51.4	0	1
7	57.6	51.3	.01	1
8	63.1	52.5	0	0
9	62.4	52.3	.02	1
10	60.4	53.5	.35	1
11	61.1	51.9	0	1
12	60.2	53.0	.55	1
13	59.1	53.0	.04	1
14	61.8	54.6	.50	1
15	65.0	54.7	0	1
16	67.5	56.6	0	1
17	65.1	57.0	0	1
18	66.2	58.5	0	1
Sept.				
10	70.5	62.5	0	0
11	66.9	54.0	.65	0
12	60.9	55.0	0	0
13	63.0	53.1	0	0
14	64.8	58.4	.03	0
15	63.8	58.9	0	0

The above estimates total 25 miles of the west end washed away or, in different terms, a minus 5 miles of island! As the 1633 size estimate differs little from the present size of the island, possible explanations are that the estimates are incorrect, that the west end was rebuilt, or that the east end has been added to as the west end disappeared. Another estimate of the island's size is mentioned by Saunders (1902). In 1901 it was said to be "about 21 miles long" with "early surveys giving the length [misreading of circumference?] as about 40 miles." If only the 1901 estimate and the 1930-39 erosion estimates are considered, the figures still do not coincide with the size of the island today. The answer seems to be partly that the estimates have been exaggerated and partly that the island is eroding on the west end and being added to at the east. This shift in position is illustrated by Grosvenor (1965). Radiocarbon dating seems to bear this out, since the oldest surface strata found on the island occur near the west end and

are less than 700 years old. Fossil peat, washing up onto the beaches (figs. 1,2), indicates that the age of the neighbouring shoal areas is nearly 7,000 years B. P. (Medioli *et al.* 1967).

The shifting position of the island is due, in part, to some of the climatic factors. Wind velocity averages about 18 m.p.h., and gales (32 m.p.h. or more) are frequent; this, coupled with wave action, accounts for most of the shifting. A detailed account of these factors and their effects is given by James and Stanley (1967). Table I lists the monthly maximum-minimum of temperature, precipitation, and wind velocity for the years 1901, 1902, 1966, and 1967. Table II gives the daily data for the periods spent on the island by the survey parties during 1966 and 1967. It is evident that Sable Island has a true maritime climate, warmer in the winter and cooler in the summer than the neighbouring mainland. During the summer, fogs are frequent because of the proximity of the Labrador Current and the Gulf Stream. The generally high humidity and the cool summer temperature undoubtedly influence insect activity. Many of the beetles seem to occur as adults over an unusually long period, and I suspect that this is characteristic of many coastal species.

LIST OF THE SABLE ISLAND COLEOPTERA

All the various factors mentioned in the preceding sections have undoubtedly had their effects on the relatively meagre fauna of the island. In the following list of species some comments, such as "probably imported in hay," will refer to the foregoing sections. Comments on distributions will be included under the discussion of zoogeography.

Each species in the list is numbered, and the number is used in tables for reference to the species. The lists of families and genera follow the arrangement in Leng (1920); species are listed alphabetically under the genera. Both an estimate of abundance (i.e., rare, uncommon, moderately abundant, and common) and the number of specimens actually taken (placed in parentheses after the estimate) are given, since in some cases only a moderate number of specimens of a readily recognizable species was taken; conversely a considerable effort was made to collect some uncommon species. Notes on the month(s) in which the species was taken and the type of area (niche) where it occurred are included. The general distribution of each species is given when possible; confused taxonomy precluded this in 14 species. A particular effort was made to check distribution records in areas adjacent to Sable Island; i.e., Newfoundland, coastal Nova Scotia, Prince Edward Island, and the New England states with particular reference to Cape Cod. Records were compiled for each species by personally checking the data on specimens housed in the Canadian National Collection, the Museum of Comparative Zoology, Harvard, and the collection of Boston University. Additional records were obtained from the literature (when the taxonomy was not in doubt). Other records were furnished by the specialists listed in the acknowledgments. If a species ranges over a wide area, only the general outline of the range is given.

Family CICINDELIDAE

1. Cicindela hirticollis Say. Common (61). June through September. On or near beach, particularly south shore; occasionally found inland near lake

margins. Range: Newfoundland and Nova Scotia west to British Columbia and south in the East to Florida and Texas.

2. *Cicindela tranquebarica* Hbst. Common (71). June through September. Found in sparsely vegetated areas away from beach. Range: Newfoundland and Nova Scotia west to British Columbia and south in the East to South Carolina and Kansas.

Family CARABIDAE

3. *Carabus serratus* Say. Rare (1). July. Under board inland near meteorological station. Range: Newfoundland and Nova Scotia west to British Columbia and south to Georgia in the East and to New Mexico and Oregon in the West.

4. *Calosoma calidum* Fab. Common (42). June through September. Occurs over inland portions of island. Active during day in well-vegetated areas. Range: Miquelon Islands, Nova Scotia, west to British Columbia, northward to Northwest Territories and south to Georgia and New Mexico.

5. *Calosoma frigidum* Kby. Rare (1). July. Taken at black light near West Light. Range: Nova Scotia and New Brunswick west to British Columbia and south to Georgia, Texas, Colorado, and Utah.

6. *Dyschirius sphaericollis* Say. Moderately abundant (21). June, July. On wet sand around lake margins, active mainly at night. Range: Newfoundland, Magdalen Islands, Quebec, west to Alberta; east of the Rocky Mountains, south to Florida.

7. *Bembidion mimus* Hayw. Uncommon (6). June through September. Under boards in moist localities inland. Range: Newfoundland, Nova Scotia, west to Manitoba and south to Illinois.

8. *Bembidion s. sejunctum* Csy. Common (80). June through September. Mainly under driftwood on beaches, particularly on north shore. Range: southern Labrador, Newfoundland, Magdalen Islands, Prince Edward Island, Nova Scotia, and Quebec; a disjunct population occurs from Alberta south to New Mexico.

9. *Pterostichus mutus* (Say). Common (61). June through September. Occurs in a variety of areas away from beaches, particularly near lakes. Range: Newfoundland, Quebec, west to British Columbia, and south through Massachusetts to Rhode Island.

10. *Amara aenea* DeG. Uncommon (9). June, July. No habitat data. European import. Range: Newfoundland, Nova Scotia, Quebec, Ontario, and Massachusetts; Europe, W. Asia.

11. *Amara familiaris* Dft. Moderately abundant (22). June, July. In dune areas behind beaches. European import. Range: Newfoundland, Nova Scotia, New Brunswick, Quebec, Ontario, Massachusetts and, as a separate introduction, British Columbia; Europe; Asia, west to Mongolia.

12. *Amara impuncticollis* Say. Rare (1). July. No habitat data. Range: Newfoundland, Nova Scotia, Quebec, Ontario, Manitoba, and Indiana.

13. *Amara quenseli* Schonh. Common (36). July through September. Under boards and litter inland; most abundant in September. A Holarctic boreo-alpine species. Concerning Sable Island specimens, Lindroth (in litt.) states "these are unusually large and belong to the flat form (probably a modification) named '*silvicola* Zimm.' in Europe." Range: Labrador, Newfoundland, Nova Scotia west to British Columbia, north to Northwest Territories and Alaska; northern and central Europe; northern Asia east to Kamchatka.

14. *Amara rubrica* (Hald.). Common (81). June through September. On surface of sand and under debris away from beaches; most abundant in September. Lindroth (in litt.) states "some are the largest specimens I have seen and therefore look strange." Range: Quebec, Ontario, Massachusetts, and New Jersey to Texas and Colorado.

15. *Amara torrida* (Ill.) (= *cylindrica* LeC.). Common (161). June through September. Occurs widely over island except on beaches. A Holarctic species. Range: Labrador, Newfoundland, New Brunswick west to British Columbia and north to the Northwest Territories and Alaska; northern Eurasia.

16. *Agonum cincticolle* (Say). Common (74). June through September. Inland under debris. Range: Ontario, Massachusetts (Nahant), south to Florida, Texas, and west to Indiana.

17. *Agonum gratiosum* Mann. Rare (4). June, July. Under debris near freshwater lakes. A northern species. Range: Labrador, Newfoundland, Prince Edward Island, Nova Scotia west to British Columbia, north to Northwest Territories and Alaska, south to Indiana and Oregon.

18. *Agonum placidum* (Say). Common (49). June through September. Under debris near lake margins. Range: Labrador, Newfoundland, Magdalen Islands, Nova Scotia west to British Columbia, south through Massachusetts (Cape Cod), and central United States to Mexico.

19. *Agonum sordens* (Kby.). Moderately abundant (30). June through September. Under driftwood on beaches. A northern species. Range: Labrador, Newfoundland, Nova Scotia, west to British Columbia, north to Alaska, Yukon Territory, and Northwest Territories, south to Massachusetts and Oregon.

20. *Metabletus americanus* (Dej.). Rare (3). June, July. Under boards. An apterous species. Range: Newfoundland, Nova Scotia, west to British Columbia, north to the Northwest Territories, south to Massachusetts, Indiana, Colorado, Arizona, and Washington.

21. *Cymindis cribricollis* Dej. Rare (1). July. No habitat data. Range: Labrador, Newfoundland, Nova Scotia, west to British Columbia, north to the Northwest Territories, south to New York.

22. *Chlaenius pensylvanicus* Say. Common (71). June through September. Found along lake margins and under boards in moist areas. Range: Newfoundland, Nova Scotia, west to British Columbia, south to Massachusetts (Cape Cod), New Jersey, Kentucky, Nebraska, Washington.

23. *Harpalus affinis* Schrk. Moderately abundant (19). June, July. Under boards, usually near lake margins. European import. Range: Newfoundland, Nova Scotia, west to Ontario, south to Florida and Kansas; as separate introduction in British Columbia and Washington; Europe; Asia east to Lena River, Siberia.

24. *Harpalus pleuriticus* Kby. Rare (1). June. Under debris near lake margin. Range: Newfoundland, Nova Scotia, west to British Columbia, north to Alaska, Yukon Territory, Northwest Territories, south to Vermont.

25. *Harpalus rufipes* (DeG.). Moderately abundant (16). June, July. Under boards inland. European import. Range: Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, Quebec; Europe; North Africa; Asia, east to Lenz River; Japan.

26. *Stenolophus fuliginosus* Dej. Rare (5). July through September. Under debris inland. Range: Newfoundland, Nova Scotia, west to British Columbia, south to Rhode Island, Pennsylvania, and Indiana.

27. *Omophron labiatum* (Fab.). Common (184). Numerous at night around freshwater lake margins. Range: Sable Island form (colour pattern differs from New Jersey - Florida specimens) also occurs on Cape Cod, Massachusetts; southern form from New Jersey along coast to Florida and west to Texas.

28. *Omophron tessellatum* Say. Common (69). July. Numerous at night around freshwater lake margins. Prince Edward Island, Nova Scotia, west to Alberta, south to Texas and Arizona.

Family HALIPLIDAE

29. *Haliplus immaculicollis* Harris. Common (130). June through September. In lakes near the west end. Range: Newfoundland, Nova Scotia, west to Alberta, south to Texas.

Family DYTISCIDAE

30. *Bidessus affinis* (Say). Common (66). June through September. In lakes near the West Light. Range: Quebec west to British Columbia, south to Massachusetts (Cape Cod), Texas, and California.

31. *Hygrotus impressopunctatus* (Schaller). Common (40). June, July. In lakes near the West Light. A northern circumpolar species. Range: Newfoundland, Nova Scotia, west to British Columbia, north to Alaska, south to Massachusetts, New York, and Indiana; northern Europe; Siberia.

32. *Deronectes griseostriatus* (DeG.). Moderately abundant (36). June through September. In lakes near the West Light. A northern circumpolar species. Range: Labrador west to Alaska (to tree line), Newfoundland, Nova Scotia, south to Massachusetts (Cape Cod), New Jersey, Iowa, Colorado, Arizona, and California; northern Europe; Siberia.

33. *Hydroporus notabilis* LeC. (= *arcticus* Thomson, fide Brown). Rare (4). June through September. In lakes near the West Light. A northern circumpolar species. Range: Labrador, Newfoundland, Quebec, west to British Columbia, north to Alaska, south to Wisconsin and South Dakota; northern Eurasia.

34. *Hydroporus signatus* Mann. Moderately abundant (31). June through September. In lakes near the West Light. Range: Labrador, Newfoundland, Nova Scotia west to Alaska, south to Massachusetts, New Jersey, and Illinois.

35. *Ilybius angustior* (Gyll.). Uncommon (8). July through September. In lakes on west end of island, mostly in September. A northern circumpolar species. Range: Labrador, Newfoundland, west to Alaska and British Columbia; northern Eurasia.

36. *Ilybius biguttulus* (Germ.). Common (79). July through September. In lakes near the West Light. Range: Nova Scotia, New Brunswick, Quebec, Ontario, Massachusetts, south to Virginia, west to Illinois.

37. *Colymbetes sculptilis* Harr. Rare (5). July. In lakes near the West Light. Range: New Brunswick, Quebec, west to Saskatchewan, south to Massachusetts, New York, and Michigan.

Family HYDROPHILIDAE

38. *Anacaena limbata* (Fab.). Rare (4). June, July. In shallows of lakes near the West Light. European import. Range: Newfoundland, Quebec, Ontario, British Columbia, and Massachusetts (Cape Cod); Europe.

39. *Enochrus hamiltoni* (Horn). Common (45). June, July. In lake shallows near the West Light. Range: eastern Canada, Massachusetts (Cape Cod area), New Jersey, west to Indiana.

40. *Cercyon haemorrhoidalis* (Fab.). Uncommon (12). June, July. In horse dung. European import. Range: Newfoundland, Nova Scotia, Quebec, Ontario, British Columbia, south to Connecticut and Indiana; Europe.

41. *Cercyon* near *pygmaeus* (111). Rare (1). July. Data uncertain, probably in horse dung. The specimen seems distinct from *pygmaeus*; the latter is European in origin, occuring in Newfoundland, south to Connecticut, and also in British Columbia.

42. *Cryptoleurum minutum* (Fab.). Uncommon (9). June, July. In horse dung. European import. Range: Nova Scotia, Ontario, British Columbia, Massachusetts, Indiana; Europe.

Family SILPHIDAE

43. *Silpha lapponica* Hbst. Rare (4). September. On carrion. A Holarctic species, occurring in North America north to tree line, rare south of Canadian border. Range: Labrador west to Alaska, south to Pennsylvania, Iowa, Kansas, New Mexico, California; northern Eurasia.

Family LEIODIDAE

44. *Leiodes assimilis* LeC. Uncommon (9). July through September. Flying at dusk and found crawling in the early evening at base of sand dunes along the north shore. Range: New Brunswick, Quebec, Ontario, British Columbia, New Hampshire, and Colorado.

45. *Bledius basalis* LeC. Rare (2). July. Collected under dead sea gull near top of north-shore beach. Range: Newfoundland, south along coast to Florida.

46. *Bledius opaculus* LeC. Common (41). June through September. Mostly along top of ocean beach under dead sea gulls. Range: Along eastern seacoast south to New Jersey.

47. *Stenus dissentiens* Csy. Uncommon (10). June, July. Under dead grass and debris near lake margins. Range: Michigan, Wyoming, Idaho, Utah, Oregon, Washington, and British Columbia.

48. *Stenus gratiosus* Csy. Common (57). June, July. Under dead grass and debris near lake margins. Range: New Hampshire, Massachusetts, Michigan.

49. *Stenus juno* (Fab.) Uncommon (14). June, July. Under debris in moist areas away from beaches. A European - North American species regarded by Lindroth (1957) as indigenous to North America. Range: Newfoundland, west to Washington, south to Massachusetts (Cape Cod) and Texas.

50. *Euaesthetus* n. sp. (?). Uncommon (11). June. Under a dead porpoise near the top of the beach on the north shore. Range: Unknown.

51. *Paederus littorarius* Grav. Common (110). June through September. Under dead grass and debris near lake margins. Range: Nova Scotia, Ontario, Manitoba, British Columbia, Northwest Territories, New Jersey, and Tennessee.

52. *Hypnogyra* sp. no. 1. Common (63). June through September. Under debris and horse dung. Range: Unknown.

53. *Hypnogyra* sp. no. 2. Uncommon (12). June through September. Under debris. Range: Unknown.

54. *Philonthus alumnus* Er. Moderately abundant (28). June, July. Under debris and carrion. A southern species. Range: New York, south to Florida, west to Arizona and California.

55. *Philonthus couleensis* Hatch. Uncommon (15). June, July. Under debris. Range: Newfoundland, Nova Scotia, Washington, and British Columbia.

56. *Philonthus cruentatus* (Gmel.). Uncommon (17). June, July. Under debris and horse dung. European import. Smetana (1965) maps the North American distribution and considers the species an introduction. Range: Newfoundland south to New York, west to Michigan; a separate population occurs in British Columbia south to Oregon; Eurasia.

57. *Philonthus debilis* (Grav.). Rare (3). June, July. No habitat data. European import. Range: Newfoundland, south to Florida, west to Indiana and Nebraska; also a western population in British Columbia, Wyoming, Idaho, and Oregon; Eurasia.

58. *Philonthus fuscipennis* (Mann.). Moderately abundant (22). June, July. Under dead grass and debris around lake margins, also under horse dung. European import. Range: Newfoundland, Nova Scotia, Ontario, south to

Virginia and Illinois; western population in British Columbia, Washington, and Oregon; Eurasia.

59. *Philonthus lomatus* Er. Common (40). June through September. Under debris, horse dung, and carrion. Range: Newfoundland, Nova Scotia, west to British Columbia, south to Florida and Indiana.

60. *Philonthus politus* (L.) Rare (1). September. Presumably under horse dung. European import. Range: Newfoundland, west to British Columbia, south to North Carolina and Oregon; Europe.

61. *Philonthus sordidus* (Grav.). Common (40). June through September. Under debris and horse dung. European import. Range: Newfoundland, west to British Columbia, south to Indiana and California; Eurasia.

62. *Philonthus varians* (Payk.). Rare (1). July. No habitat data. A cosmopolitan species according to Smetana (1965). Range: Newfoundland, west to British Columbia, north to Northwest Territories, south to New Jersey, Colorado, and Arizona; Eurasia.

63. *Philonthus varius* (Gyll.) Common (84). June through September. Under debris, horse dung. European import. Range: Newfoundland, Nova Scotia, west to British Columbia, north to Northwest Territories, south to Illinois, and Oregon; Eurasia.

64. *Philonthus vulgatus* Csy. Uncommon (11). June through September. Under debris and carrion. Range: Nova Scotia west to Alaska, south to New York and California.

65. *Ocypus ater* (Grav.). Rare (4). July through September. No habitat data. Probably European import. Range: Newfoundland, west to British Columbia, south to New Jersey, Louisiana, and California; Europe.

66. *Creophilus maxillosus villosus* (Grav.). Common (42). June to September. Mostly under horse dung and old carrion. North American specimens differ slightly from European ones. Range: Newfoundland, Nova Scotia, west and south over much of North America to Central America.

67. *Heterothops fusculus* LeC. Rare (2). July through September. No habitat data. Range: Newfoundland, Michigan, west to California.

68. *Quedius mesomelinus* (Marsch.). Rare (4). July. Taken in old starling nest. A cosmopolitan species according to Smetana (1965). Range: Labrador, Newfoundland, west to British Columbia and Alaska, south to New York, Iowa, and California.

69. *Conosoma pubescens* Payk. (of Horn) (? = *testaceum* Fab.). Rare (1). No habitat data. Possibly European import. Taxonomy of North American specimens confused at present. Range: Unknown.

70. *Tachyporus jocosus* Say. Common (112). June through September. In dead grass and litter around lake margins. Range: Connecticut, west to Michigan and Indiana, south to Florida.

71. *Mycetoporus americanus* Er. Rare (9). June, July. No habitat data. Range: Pennsylvania, south to Florida, west to Illinois.

72. *Atheta* sp. Common (187). June, July. Under horse dung and litter. Range: Unknown.

73. *Gnypeta* sp. Rare (6). July. No habitat data. Range: Unknown.

74. *Falagria dissecta* Er. (or near). Rare (9). June through September. Under debris near lake margins. Range: southeastern Canada, south to New York, west to Colorado and New Mexico.

75. *Oxypoda* sp. no. 1. Rare (2). July. No habitat data. Range: Unknown.

76. *Oxypoda* sp. no. 2. Rare (5). June through September. No habitat data. Range: Unknown.

Family HISTERIDAE

77. *Hister curtatus* LeC. (= *lacustris* Csy.). Rare (2). July. Under carrion. Range: Michigan, South Dakota, Indiana, Tennessee, South Carolina.

78. *Hypocaccus fraternus* (Say). Common (180). June through September. Many found crawling on surface of sand, also common under horse dung and carrion. Range: Quebec west to Saskatchewan, south to Massachusetts (Cape Cod area), Virginia, Mississippi, Texas, and New Mexico.

79. *Baeckmanniolus palmatus* (Say). (= *dimidiatipennis* LeC.). Common (50). June, July. Many found crawling on surface of sand, also under horse dung and carrion. According to Wenzel (in litt.) *palmatus* is primarily a coastal species and is closely related to two European species, *B. maritimus* (Steph.) and *B. dimidiatus* (Ill.). Range: Quebec (?), Maine, Massachusetts (Cape Code area), south to New Jersey.

Family OEDEMERIDAE

80. *Nacerda melanura* (L.). Moderately abundant (27). July. Taken under old driftwood at top of ocean beach. Larvae found in same situation in June. A cosmopolitan species, often common in coastal areas. Range: Nova Scotia, New Brunswick, west to British Columbia, southward; Europe.

Family ANTHICIDAE

81. *Malporus formicarius* (Laf.). Common (221). June through September. In litter and dead grass around lake margins. Range: Ontario, Massachusetts (Cape Cod area), Rhode Island, west to Iowa.

82. *Sapintus pusillus* (Laf.) (= *festinans* Csy.). Uncommon (15). In dead vegetation around lake margins. Range: Quebec, Massachusetts (Cape Cod area), south to Florida, west to Colorado.

Family ELATERIDAE

83. *Negastrius delumbis* (Horn). Common (183). June, July. Found in sand dune areas at base of marram-grass (*Ammophila breviligulata*) and under *Cakile edentula* at top of beach. A flightless, coastal sand dune species. Range: Prince Edward Island (Cavendish), Nova Scotia (Lawrencetown),

Maine (Kennebunk beach), Massachusetts (Truro), and New York (Rivermead, Long Island).

84. *Dalopius pallidus* Brown. Common (71). June through September. Taken sweeping herbaceous vegetation. Range: Newfoundland, Nova Scotia, west to Saskatchewan, south to Massachusetts (Cape Cod area) and Illinois.

85. *Agriotes fucosus* (LeC.). Uncommon (18). June, July. Under boards in areas of mixed vegetation near the West Light. A species usually associated with well drained forest margins. Range: Newfoundland, south to Maine and New Hampshire, west to Alberta, South Dakota, and Nebraska.

Family HETEROCERIDAE

86. *Neoheterocerus fatuus* (Kies). Common (58). June, July. In shallows along lake margins. Largely a coastal species. Range: New Brunswick, south to New Jersey.

Family EUCINETIDAE

87. *Eucinetus terminalis* LeC. Uncommon (14). July through September. Mostly under boards in cranberry (*Vaccinium macrocarpon*) bogs. Range: Ontario, west to Saskatchewan, south to Vermont, Indiana, and Illinois.

Family BYRRHIDAE

88. *Cytilus alternatus* (Say) (= ? *sericeus* Forst. of Europe). Moderately abundant (27). June, July. Near lake margins, some under boards. Range: Newfoundland, Nova Scotia, west to British Columbia, north to tree line, south to Massachusetts, Pennsylvania, and Colorado.

Family NITIDULIDAE

89. *Omosita colon* (L.). Uncommon (13). June, July. On and under old carrion. Considered a European import, now essentially cosmopolitan. Range: Newfoundland, west to British Columbia, south through Massachusetts to the southern United States; Europe.

Family CRYPTOPHAGIDAE

90. *Cryptophagus fallax* Bal.-Brn. (?). Rare (2). July. Presumably in sparrow nests. Probably European import. Range: Maine (Mt. Desert Isle); British Isles, Northern Europe.

91. *Anchicera ochracea* Zimm. Moderately abundant (34). July through September. In straw and sparrow nests. Possibly brought in hay from mainland. Range: Ontario west to Manitoba, south to Maryland and Indiana.

Family LATHRIDIIDAE

92. *Lathridius minutus* (L.). Common (73). July through September. In straw and sparrow nests. Possibly brought in hay from mainland. European import, now a cosmopolitan species. Range: Newfoundland west to Alaska, south through most of the United States; Europe.

93. *Thes bergrothi* (Reitt.). Rare (1). July. In straw. Possibly brought in hay from mainland. European import. Range: New Brunswick, Manitoba, Saskatchewan, Washington; Europe.

94. *Microgramme ruficollis* (Marsh.). Moderately abundant (34). July. In straw and chicken litter. Possibly brought in hay from mainland. European import. Range: Quebec, west to British Columbia, south to Massachusetts and Oregon; Europe.

95. *Melanophthalmia* near *cavicollis* Mann. Uncommon (18). June through September. In dead vegetation around lake margins. Range: Unknown.

96. *Malanophthalmia* near *pusilla* Mann. Common (47). June through September. In dead vegetation around lake margins. Range: Unknown.

Family MYCETAEIDAE

97. *Mycetaea hirta* (Marsh.). Rare (1). July. No habitat data. European import. Range: Quebec, Ontario, British Columbia, Massachusetts, south to Maryland, west to Michigan; Europe.

Family COCCINELLIDAE

98. *Coccinella u. undecimpunctata* L. Common (77). June through September. In mixed vegetation inland. European import. Range: Newfoundland, Prince Edward Island, Nova Scotia, west to Ontario, south to Massachusetts (Cape Cod area) and New York; Europe.

Family TENEBRIONIDAE

99. *Blapstinus* near *metallicus* (Fab.). Uncommon (17). June through September. Crawling on sand inland. Range: Unknown, but seemingly conspecific specimens examined from Cape Cod, Massachusetts, and coastal areas to the south.

100. *Ephalus latimanus* (LeC.). Common (254). June through September. Commonly found at night on the sand in the lower parts of the dune-grass formations. A flightless, coastal sand dune species. Range: Massachusetts (Cape Cod), south to New Jersey.

Family PTINIDAE

101. *Ptinus fur* (L.). Uncommon (15). July. Feeding on insect fragments in heated quonset hut at West Light. The only species found on the island that occurred only in heated buildings. European import, essentially cosmopolitan. Range: Nova Scotia, west to British Columbia and southward; Europe.

Family SCARABAEIDAE

102. *Onthophagus nuchicornis* (L.). Common (47). June, July. Only in horse dung. European import. Range: Newfoundland, Nova Scotia, west to Ontario, south through Massachusetts (Cape Cod area) to Maryland; occurring as separate population from British Columbia to Idaho; Europe.

103. *Aegialia arenaria* (Fab.). Common (289). June through September. Mainly in dune, marram-grass areas; often seen crawling on surface. A flightless species. Considered a European import, but I have some reservations. Darlington (1927) first reported the species from North America (Ispwich, Mass.) It has not been reported from other areas. The Cape Cod - Sable Island distribution is not a typical import pattern, hence my reservations. Range: Massachusetts; Europe.

104. *Aegialia spissipes* LeC. (= ? *rufa* Fab. of Europe). Uncommon (10). July. Found crawling on sand at base of high dunes along beach between 6 and 7 p.m. Landin (1960) has questioned whether *spissipes* LeC. and *rufa* Fab. are distinct. So little material is presently available that the question seems difficult to resolve. If *spissipes* is the same as the European species, *rufa,* its rarity on both continents and its wide North American range make any explanation of its distribution difficult, particularly if one argues that it is a European import. At present, considering its range and the presence of other related species, I consider *spissipes* native to North America. Range: Miquelon Islands, south to Massachusetts (Cape Cod area), west to Michigan.

105. *Aphodius fimetarius* (L.). Common (33). June, July. In horse dung. European import. Range: Newfoundland, Nova Scotia, west to British Columbia, south through much of the United States; Europe.

106. *Aphodius subterraneus* (L.). Common (65). June, July. In horse dung. European import. Range: Nova Scotia, New Brunswick, Quebec, and New Jersey; Europe.

107. *Serica tristis* LeC. Moderately abundant (38). June through September. Adults flew in daytime, feeding mainly on leaves of *Rubis.* Most common in area of meteorological station on west end of island. Range: Prince Edward Island, Nova Scotia west to Manitoba, south to Massachusetts (Cape Cod area), and New York.

108. *Phyllophaga drakii* (Kby.). Common (68). June through September. Adults most active in early evening, feeding on several herbaceous plants including *Rubis.* Larvae found around roots of marram-grass (*Ammophila breviligulata*). Range: Nova Scotia, New Brunswick, west to Wisconsin, south through Massachusetts (Boston area) to Georgia.

Family CHRYSOMELIDAE

109. *Phaedon* near *oviformis* LeC. Common (182). June, July. Around lake margins, most common in early June. Range: Unknown, but seemingly conspecific specimens seen from Quebec (Fall collection), and from Massachusetts (Woods Hole and Nantucket).

110. *Pyrrhalta sablensis* Brown (1969). Moderately abundant (85). June, July. Adults and larva found feeding on cranberry (*Vaccinium macrocarpon*), seemingly restricted to one small area near a small freshwater lake just east of the West Light. The lake, which had a salinity of 25 parts per million, was less saline than any of the surrounding lakes. Range: Sable Island.

111. *Altica potentillae* Brown. Moderately abundant (32). June, July. Majority taken feeding on *Potentilla anserina.* Range: Nova Scotia, west to British Columbia, south to Massachusetts (Nantucket).

112. *Mantura floridana* Crotch. Moderately abundant (35). June, July. Majority taken feeding on *Rumex crispa.* Range: Newfoundland, Nova Scotia, west to Manitoba, south through Massachusetts to Florida and Texas.

113. *Phyllotreta chalybeipennis* (Crotch.). Common (120). June, July. Feeding on *Cakile edentula* growing near top of ocean beach. Range: Massachusetts (Nantucket and Marion), south along coast to Florida.

114. *Brachyrhinus ovatus* (L.). Moderately abundant (29). June, July. Mostly under boards in grass-herbaceous areas. European import. Range: Newfoundland, Nova Scotia, west to British Columbia, south to Massachusetts (Cape Cod area), New Jersey, Iowa, and Colorado; Europe.

Family CURCULIONIDAE

115. *Brachyrhinus sulcatus* (Fab.). Common (47). June through September. Mostly under boards in mixed herbaceous areas. European import. Range: Newfoundland, Nova Scotia, west to British Columbia, south to Massachusetts (Cape Cod area) and North Carolina in east, California in west; Europe.

116. *Sitona scissifrons* Say (a complex of forms). Common (42). June through September. Majority taken sweeping beach pea (*Lathyrus japonicus*) in dune areas. Range: Nova Scotia, New Brunswick, south to Massachusetts (Cape Cod area), and west to (at least) Manitoba and Iowa.

117. *Hypera nigrirostris* (Fab.). Rare (1). July. No habitat data. European import. Range: Newfoundland, Nova Scotia, west to Ontario and Wisconsin, south to Maryland; also, as separate population, in British Columbia; Europe.

118. *Hypera punctata* (Fab.). Rare (2). July. Sweeping herbaceous vegetation near lakes. European import. Range: Newfoundland, Nova Scotia, west to British Columbia, south to Maryland, Texas, and California; Europe.

119. *Hyperodes* sp. Common (135). June, July. Most taken sweeping herbaceous vegetation, particularly in areas near lakes. Range: Unknown because of confused taxonomy; seemingly conspecific specimens seen from Prince Edward Island, Nova Scotia, and Massachusetts (Cape Cod area).

120. *Notaris bimaculatus* (Fab.). Moderately abundant (32). June through September. Mostly found crawling on sand in beach-dune area. Differs slightly from majority of mainland specimens in appearing to be less robust. A northern species. Range: Nova Scotia, New Brunswick, west to Alberta, north to Northwest Territories and Alaska.

121. *Rhynchaenus pallicornis* (Say). Common (105). June through September. Taken sweeping herbaceous vegetation near lakes. Range: Nova Scotia, New

Brunswick, west to British Columbia, south to Massachusetts (Cape Cod area) and Kansas.

122. *Ceutorhynchus hamiltoni* Dietz. Rare (1). July. On *Cakile edentula.* Range: Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Massachusetts (Cape Cod area), and Rhode Island.

123. *Phytobius* near *sulcicollis* Fahr. Rare (1). July. No habitat data. Range: Unknown (of *sulcicollis*–Ontario, Quebec, south to Maryland).

124. *Anthonomus signatus* Say. Common (56). June through September. On herbaceous vegetation near lakes. Range: Prince Edward Island, Nova Scotia, west to British Columbia, south to Massachusetts (Cape Cod area) and North Carolina.

125. *Rhinoncus castor* (Fab.). Uncommon (10). June, July. Mostly on *Rumex.* European import. Range: Newfoundland, Prince Edward Island, Nova Scotia, west to British Columbia, south through Massachusetts (Cape Cod area) to Florida; Europe.

126. *Sphenophorus cariosus* (Oliv.). Moderately abundant (20). June, July. Crawling on ground in grass areas near lakes. Range: Massachusetts (Cape Cod area), south along coast to Florida and Louisiana.

TABLE III

Distributions of Sable Island Coleoptera

Hudsonian-Canadian Zone	Eastern	–	–
	Transcontinental	17, 19, 21, 24, 34, 88	6
	Circumpolar	13, 15, 31, 32, 33, 35, 43	7
Primarily Canadian Zone	Coastal	83, 110, 122	3
	Eastern	8, 37, 85, 104	4
	Transcontinental	44, 55, 120	3
	Circumpolar	–	–
	Introduction	25, 38(?), 63, 90, 103(?), 106	6
Canadian-Transition Zone	Coastal	45, 86, 100	3
	Eastern	6, 7, 12, 14, 36, 39, 48, 74, 77, 78, 79, 84, 87, 91, 107, 108, 112, 116	18
	Transcontinental	1, 2, 3, 4, 5, 9, 18, 20, 22, 26, 28, 29, 30, 47, 51, 59, 64, 67, 111, 121, 124	21
	Circumpolar	49(?), 62(?), 66, 68, 80(?)	5
	Introduction	10, 11, 23, 40, 42, 56, 57, 58, 60, 61, 65, 89, 92, 93, 94, 97, 98, 101, 102, 105, 114, 115, 117, 118, 125	25
Primarily Austral Region	Coastal	27, 46, 99, 113, 126	5
	Eastern	16, 54, 70, 71, 81, 82	6
	Introduction	–	–
		Total	112 (126)

ZOOGEOGRAPHIC RELATIONSHIPS

The previous section includes the known distribution of each beetle species, with particular reference to eastern Canada and the northeastern United States. At best the distributions are incomplete, for in many cases the species either are poorly known or have been poorly collected. However, the general distributional picture given is fairly reliable for 112 of the 126 species. In attempting to chart these 112 distributions, some type of north-south grouping was necessary, and I elected to use various combinations of Merriam's classification of North America, i.e., Boreal Region with the Arctic, Hudsonian, and Canadian zones; Austral Region with the Transition, Upper and Lower Austral zones. Generally, various combinations of zones are used, as few species are limited to one zone or, in a few cases, to one region. Even then, species are listed as occurring primarily in one or more zones when occasionally recorded from other zones or regions. The east-west grouping within the various divisions in the chart seems self-explanatory, "coastal" referring to the East Coast only. In Table III, species are referred to by the number used in the list, and if there is any doubt that a species is an import, the number is followed by a question mark. The east-west divisions have been omitted from the table when not pertinent. In a few cases they have been included to emphasize the fact that none of the species fall within a particular category.

If one views the distributions outlined above as they relate to Sable Island and if one considers the climate and location of the island, it becomes evident that there is an unusual mixture of faunas. The island represents essentially the southern limits of the ranges of the species listed under the Hudsonian-Canadian zones. Conversely most of the species listed as Austral have their northern limits on the island. A number of the latter, *Omophron labiatum* (27), *Philonthus alumnus* (54), *Phyllotreta chalybeipennis* (113), *Sphenophorus cariosus* (126), and in addition, *Hister curtatus* (77), *Cryptophagus fallax* (90), *Ephalus latimanus* (100), and *Aegialia arenaria* (103) have not been previously reported from Canada. Part of the explanation for this undoubtedly is the maritime climate: the relatively warm winter allowing the survival of some southern forms, the cool summers making possible the survival of northern forms.

Interpretation of the other faunal elements necessitates comments on the general distributions of the various species. It is not surprising that the Hudsonian-Canadian species are either transcontinental or circumpolar, since these are the usual patterns for much of the northern biota. The small number of species considered as occurring primarily in the Canadian zone is an indication that few are restricted to this zone. This may be attributable to the effects of the Pleistocene glaciations. A large portion of the zone was glaciated, with the resulting extinction of relatively sedentary species. Survival had to be in peripheral areas in Alaska, in coastal refugia, or in areas to the south. The large number of species occurring today in the Canadian-Transition zone is indicative of reinvasion from the south. This seems to support the idea that if there was a distinct beetle fauna occurring primarily in the Canadian zone before the last glaciation, it was largely eliminated (Howden 1969). The coastal and eastern species considered as belonging to the Canadian zone survived either just south of the glacial limits or in an offshore refugium. The possibility of the latter will be considered subsequently. Species listed as

introductions (?) might be circumpolar, and, conversely, species listed for the Canadian-Transition zone as circumpolar (?) might be introductions. The latter, including those listed as introductions, have been included in the zone on the basis of both their distribution in North America and in the Palearctic region.

In the Canadian-Transition zone, 86 per cent of the transcontinental species occurring on Sable Island are predators. Normally species associated with the coniferous forest constitute the conspicuous transcontinental elements, but since trees are lacking on Sable Island and few plants native to the island have a transcontinental range, it is not surprising that the ubiquitous North American species occurring on Sable Island are largely predaceous. In general, predatory species often have a wide food selectivity, and, of necessity, are more motile than their prey. The same statements are true, but to a lesser extent, for the Eastern Canadian - Transition zone species; of these, 61 per cent are predators.

The species considered to be European imports on Sable Island comprise 24 per cent of the total beetle fauna (only 20 per cent of the vascular plants are European, according to Erskine (1954)). This is not surprising if one considers the large number of imported species occurring in adjacent areas of the Canadian maritimes (Lindroth 1957). Some of the species may have come, via shipwreck, direct from Europe. If many arrived in this manner, and if one considers the number of shipwrecks (well over 200), it seems odd that all the European species that occur on Sable Island are found also in adjacent coastal localities of North America. Other aspects such as the ballast theory, have been discussed under the heading "Activities of Man on Sable Island". There does seem to be a strong possibility that many of the European species that first became established on the Canadian mainland were then brought to Sable Island with livestock or in hay, straw or produce. In the chart there are no imports listed as occurring on Sable Island for the Austral region. A number of imports exist there, but none have become established on Sable Island. Several species, particularly *Cryptophagus fallax* (90) and *Aegialia arenaria* (103), that are considered introductions, have rather unusual restricted ranges in North America, not unlike the restricted coastal ranges of a few native species. I wonder, as have Darlington (1927) and others, about the possibility of some species having relict amphi-Atlantic distributions. If, at times of lowered sea levels, exposed portions of the continental shelf could serve as refugia, there could also be the possibility that a few species have natural amphi-Atlantic distributions. At present it seems best not to speculate on the question of amphi-Atlantic distributions. However, the question of offshore refugia during the Pleistocene in the vicinity of Sable Island is worthy of consideration.

THE SABLE ISLAND AREA – A PLEISTOCENE REFUGIUM?

Certain elements of the flora and fauna surrounding the Gulf of St. Lawrence have long puzzled biologists. Many beetles that occur in the Maritime region attain their maximum size on Newfoundland. Lindroth (1963) discussed this phenomenon as seen in some ground beetles (Carabidae) and concluded that "the presence of populations deviating in size from what is normal within the species should not be used as an argument in favor of longtime isolation and 'subspecies'

should not be founded on differences in size alone." Despite this, Lindroth (1963: 107) does consider that some carabids may have survived the last glaciation on or near Newfoundland. Munroe (1956) cited a number of papers pertaining to the controversy about a refugium in the area and concluded that, while theories on migrating biotas may be largely correct, they do not, "however, account for the general occurrence of endemics and disjuncts in the Gulf region, at low levels as well as high both as localized forms and as radiants in Labrador and elsewhere in the Northeast. An eastern refugium separate from the general southern glacial-margin strip is required."

The validity of the above is contingent upon the geological history of the Sable Island and Grand Banks areas. Were they emergent during intervals of lower sea levels and were they unglaciated? Could they have served as refugia during the Pleistocene or, more particularly, during the last (Classical Wisconsin) glaciation?

Theories concerning the age of the Sable Island formation and its origin are as confusing and controversial as some of the historical aspects. There can be no doubt that the present emergent area, i.e., Sable Island, has shifted. This makes carbon dating of surface features nearly useless. Cameron (1965) and James and Stanley (1967) discussed the shifting nature of the island. Cameron (1965) also suggested that it was formed from outwashings of glacial till, speculating that currents caused a 1,400-foot dome of sand to be formed over "bedrock" and that the age of the emergent area is no more than 6,000 years. Erskine (1954) discussed a similar hypothesis, but in less detail. In a recent analysis of the geology of the area Stanley and Cok (1967) presented evidence and ideas concerning the extent of the Wisconsin glaciation and concerning unglaciated areas that were probably exposed during periods of lowered sea level. Their findings coincide to a considerable degree with unpublished data accumulated by Drs. V. K. Prest and J. Terasmae of the Geological Survey of Canada. In general the Sable Island Banks represent an old formation, being, according to Stanley and Cok, "essentially erosional in origin and consisting of sedimentary deposits of late Mesozoic to Tertiary age." Near and on Sable Island there is a thin overlay of Pleistocene age, attaining on Sable Island an approximate depth of no more than 200 feet (Terasmae, pers. comm.). As shown on Map 2 and also by Stanley and Cok, a considerable portion of the Sable Island bank was exposed and unglaciated during the last maximum. The question remains, could and did this area serve as a refugium for plant and animal life?

From work done by Lindroth (1965) and others, there seems little doubt that a considerable flora and fauna can survive adjacent to a glaciated area. Undoubtedly much depends on climatic factors, and I am not qualified to speculate on the possible Pleistocene climate of the Sable Banks. The position of the Gulf Stream during that time would be very important. With the emergent areas of the Grand Banks possibly deflecting the Labrador Current, the Gulf Stream may have been even closer to the Sable Island area than its present distance of 50 miles. If true, a narrow coastal strip may have had a relatively mild climate.

Good biological evidence for a refugium is scanty. Fossil peat from 8,000 to 10,000 years old (C14 dated) occurs in the area, having washed up from presently submerged areas. This suggests that a larger vegetated area certainly

existed during those times. Further to the south, evidence derived from elephant teeth (Whitmore *et al.* 1967) and from fossil peat (Emery *et al.* 1967) indicates that there was undoubtedly a considerable biota present on exposed areas of the continental shelf during the last glacial maximum. Sable Island, if the geological evidence is correct, is the last exposed remnant of a much larger area. However, because of its shifting location, the length of time that the biota has been in residence remains problematical. Some extinction of the fauna has undoubtedly occurred with the reduction of the land area, and further disruption has resulted from the activities of man by his importation of plants and animals. How long the native elements have been established is a matter for speculation, since no fossils are available. The only vertebrate animal possibly indicative of an extended period of residence is the Ipswich Sparrow, and this subject is controversial. Since more species of insects can live in a small area, they seem more useful than vertebrates as indicators of a possible refugium, at least for Sable Island.

Of the beetles, only one species, *Pyrrhalta sablensis* (110), is seemingly endemic to the island. The species is closely related to a few mainland forms but is undoubtedly distinct on the species level. Since the species is winged and since there is seemingly no way to judge the time needed for divergence, its presence is not necessarily indicative of a long residence. The flightless click beetle *Negastrius delumbis* (83) occurs in coastal sand dune areas from Prince Edward Island, south along the coast of Nova Scotia, then to Cape Cod, Massachusetts, and coastal Rhode Island. Most, if not all, of the mainland areas in which the click beetle now occurs were glaciated. Its spotty and relatively limited distribution and its inability to fly make the present range difficult to explain, unless one considers survival during the Pleistocene in areas presently submerged. The same can be said for the tenebrionid *Ephalus latimanus* (100). This large flightless species (fig. 8) is common on Sable Island and occurs in dune areas to the south from Cape Cod to New Jersey. Another species with the same northern coastal type of distribution is the winged weevil *Ceutorhynchus hamiltoni* (122), which occurs on *Cakile* along ocean beaches from Newfoundland south to Rhode Island.

Two other groups also warrant consideration. One contains northern forms, occurring largely in Canada, with Sable Island now representing, essentially, the southern end of their distributions. The weevil *Notaris bimaculatus* (120) belongs to Holarctic, northern genus, with Sable Island representing primarily one of the more southern portions of its range. Specimens from Sable Island and the adjacent maritime regions are more slender than more inland forms, and there is the possibility of some confusion in their taxonomy. Other species that belong in this 'northern' group are *Bembidion sejunctum* (8), *Colymbetes sculptilis* (37), *Agriotes fucosus* (85), *Aegialia spissipes* (104), *Serica tristis* (107), and some Staphylinidae. Both *Agriotes fucosus* and *Serica tristis* are species usually found along woodland margins: their presence on Sable Island could be indicative of an adaption to coastal conditions as the emergent areas gradually reduced in size. *Phyllophaga drakii* (108) is another species with a more southern range, usually associated with open woodland areas.

Map 2 – Emergent areas of Sable and Grand Banks during the Classical Wisconsin glaciation

The last group contains southern (Austral) coastal species, with the northern end of their range on Sable Island. These are *Omophron labiatum* (27), *Bledius opaculus* (46), *Blapstinus* near *metallicus* (99), *Phyllotreta chalybeipennis* (113), and *Sphenophorus cariosus* (126). Although all of these may be capable of flight, none, except perhaps the *Phyllotreta,* can be considered strong fliers. None of the species have been found on the adjacent mainland of Nova Scotia, the Cape Cod area being, in most cases, the northern point of their mainland distribution. In *Omophron labiatum,* specimens from Sable Island and Cape Cod consistently differ in colour pattern from more southern specimens; no other differences have been noted.

Since it is well known that the ranges of both northern and southern forms often extend further south or north along the coast, these elements are to be expected and, in themselves, throw little light on the age of the island. However, when considered in conjunction with the presence of flightless species and the present isolation of the island (more than 90 miles from the nearest point of land), they can best be explained by the theory of dispersal over large, emergent, coastal areas during times of lowered sea level. The importance of dispersal by wind or currents (Darlington 1938) is nearly impossible to assess. Major storms in the Sable Island area occur most frequently during the fall and winter, when there is little insect activity. Because of this, I consider wind transport of the flightless or heavy-bodied insects as less likely in the Sable Island area, particularly over the water gaps as they now exist, than it might be in areas further to the south.

The Sable Island Banks and adjacent areas during the Pleistocene probably resembled physiographically the present, somewhat dissected, coastal areas stretching from New Jersey to South Carolina. Faunal dispersal along this coast appears to be relatively easy, with a few areas, such as Chesapeake Bay, constituting barriers for some species. The derivation of the native Sable Island beetle fauna can, conceptually, be best explained by their having dispersed during a time when there were large areas exposed with only relatively minor water barriers interrupting north-south migrations.

In considering the fauna of Sable Island, its possible origins, and its methods of dispersal, comparisons have been largely made with adjacent areas of the mainland, in relation to both the native and the imported elements. A comparison of the Sable Island fauna with that of another essentially similar island is the next desirable step. Unfortunately, there is no really suitable island for such a comparison. The most similar, at least in climatic respects, is Iceland, where most, if not all, of the fauna seems to be postglacial in origin. According to Larsson and Gigja (1959), not more than 160 species of beetles breed in Iceland. Of these, probably 25 or more cannot survive outside heated buildings. Of the 126 species on Sable Island, all but *Ptinus fur* breed outdoors; thus the two islands have essentially the same number of free-lving species. Larsson and Gigja believe that 81, or 50 per cent, of the 160 species living on Iceland are imports. Of the 125 free-living species, 56 or 42 per cent, are imports. However, they consider as indigenous to Iceland 12 species that are imports in North America; this suggests that their percentage of imports is much too low. Of the free-living species, only 8 species are common to both Sable Island and Iceland, and these are surely imports to both.

Essentially, Iceland has nearly twice the number (or percentage) of imported free-living species as are found on Sable Island. Some of this difference between the two islands is certainly due to their proximity to different faunal regions; the rest might be the result of different glacial histories, ecological factors, differences in types of imports, or other unrecognized factors. These, unfortunately, seem to exclude speculation on the relative ages of the two faunas. However, if the variables can be considered to be roughly equal, then it might be argued that Sable Island has the older fauna. Iceland has an area of approximately 30,000 square miles, over 100 times the size of Sable Island. Climatically the two are rather similar. The weather data for Vestmannaeyjar, Iceland, are as follows: mean temperatures: January, 34.5°F; April, 39.6°F; July, 52.6°F; October, 42.1°F; record extremes: 71°F maximum, -6°F minimum. Rainfall averages 52.9 inches per year. These data are very similar to those for Sable Island as given in Table I. If one utilizes the theories of MacArthur and Wilson (1967), Iceland is about 5 times as far from its faunal source area (for beetles) as is Sable Island, but it has 100 times the area of Sable Island. Therefore, if time is not a factor, it might be expected to support a larger fauna. Since both islands support 125 free-living species, the time available for faunal invasion may be a factor that explains at least part of this discrepancy. Iceland was largely glaciated, and Sable Island seemingly was not, so the above comparison at least does not refute the idea of faunal survival on Sable Island during the Pleistocene.

CONCLUSIONS

The presence of endemic species and the seemingly unusual distributions of some animals and plants occurring in the Canadian maritimes and around the Gulf of St. Lawrence have caused numerous workers interested in biogeography to theorize on the possibility of an offshore refugium during the last glacial maximum. Recent geological work lends credence to this biological theorizing. From the geological standpoint there is considerable evidence that large areas in the vicinity of Sable Island were exposed and unglaciated during the Classical Wisconsin Maximum. Unfortunately the geological evidence does not at present give any indication of the composition of the Pleistocene biota of the area or even of whether there was any.

The biological evidence is still inconclusive, but the information available seems to support, or at least does not refute, the theory of offshore refugia. Of the 126 species of Coleoptera on Sable Island, about 12 per cent have distributions most easily explained by invoking the concept of offshore refugia. Only one species, *Pyrrhalta sablensis,* is endemic. Explaining the presence of others, such as the flightless *Negastrius delumbis* and *Ephalus latimanus,* by chance dispersal over the present water barriers is difficult; their dispersal over relatively narrow water barriers seemingly is a more logical hypothesis.

The assumption that the Sable Island area and adjacent banks served as refugia during the last Wisconsin Maximum seems reasonable on the basis of present data. During glacial expansion, offshore areas became exposed and available for invasion from the mainland. Water barriers were greatly reduced, and north-south movement along the newly exposed shore-lines perhaps accounted for the present

odd mixture of northern and southern species now present on Sable Island. During glacial recession, reinvasion of the newly exposed areas of mainland initially must have been relatively easy, becoming less so with rising sea levels. Reduction in the size of Sable Island and inundation of other areas have undoubtedly caused the extinction of much of the biota. However, a small fraction of the fauna does seem to support the concept of the area serving as a Pleistocene refugium.

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THE ODONATA AND ORTHOPTERA

By J.E.H. MARTIN*

ODONATA

During the summer of 1967 five species were collected and found breeding on the island. Nymphs of all species except *Sympetrum corruptum* (Hagen) were obtained, and teneral adults of this species were collected on the margin of the freshwater lake near the West Light.

ZYGOPTERA

Family COENAGRIIDAE

Enallagma civile (Hagen)

Adults: 21♂ 15♀, 1-18 July 1967; 15♂ 11♀, 11-18 September 1967.

Nymphs: Numerous nymphs collected on the above dates.

Range: Arizona to Florida, south to W. Indies and Colombia, north in Canada to Nova Scotia and New Brunswick, southern and western Ontario, Manitoba, and Saskatchewan.

This species has not been collected in Quebec, and Walker (1953: 208) suggests it has entered the Maritime Provinces from the New England states. Nymphs were abundant in all the freshwater ponds and lakes.

Ischnura verticalis (Say)

Adults: 88♂ 69♀, 1-18 July 1967; 2♂ 1♀, 13 September 1967.

Nymphs: Numerous nymphs collected on the above dates.

Range: An eastern species, Newfoundland to Manitoba, south to South Carolina and Texas.

Walker (1953: 260) states that this species is "rather a feeble flyer and seldom, if ever, ventures over the open water of a pond or stream."

This was the most abundant species on the island, nymphs being taken in all freshwater ponds and lakes.

ANISOPTERA

Family AESHNIDAE

Anax junius (Drury)

Adults: 2♀, emerged Ottawa, Ontario, 1 August 1967, nymphs collected 15 July 1967.

Nymphs' 3♂ 6♀, collected same date.

Range: A wide-ranging migratory species; occurring throughout North America, Alaska to Panama, West Indies, Hawaiian Islands, and west coast of Asia.

Nymphs were collected from only one pond located near the Meteorological Station.

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*Entomology Research Institute, Canada Department of Agriculture, Ottawa.

Family LIBELLULIDAE

Sympetrum corruptum (Hagen)
Adults: 2♀, 15-16 July 1967.
Nymphs: Not observed.
Range: Southwest Ontario to British Columbia, south to Baja California and Mexico, east to Florida, and north to New York.
This species has not been collected in Quebec or the Maritime Provinces and was uncommon on the island.

Sympetrum rubicundulum (Say)
Adults: 5♂, 11-15 July 1967.
Nymphs: Many, on the above dates.
Range: Eastern Canada, south to Virginia, west to Utah, and north to South Dakota.
Nymphs were numerous in all freshwater ponds and lakes.

ORTHOPTERA

The only orthopteroid insect collected during the three visits to the island in 1966 and 1967 was *Melanoplus sanguinipes* (Fab.). This species, reported by Piers (1896: 216) as *Melanoplus atlantis* (Riley), is probably the first insect recorded from Sable Island. One male and three females taken on September 23, 1894, were received by Piers from the Marine and Fisheries Department, which reported that these insects had become "a frightful scourge" on the island. Piers, from information received from the superintendent, stated that locusts had not been observed on the island prior to 1891, but because of exceedingly dry summers they attained devastating numbers by 1895. Garden crops were destroyed, and damage reached such proportions that it was necessary to import quantities of hay to feed the ponies. Piers (1918: 293) made further reference to the outbreak and from correspondence with the superintendent of the island reported that on June 11, 1896, millions of young locusts appeared; fortunately, a cold wet period followed, which presumably destroyed the young insects. Piers stated locusts had not been seen on the island since 1896 and suggested that in 1891 they had flown to the island, aided by the prevailing southwest wind. The possibility that the species did in fact exist unnoticed on the island prior to 1891 and following 1896 cannot be excluded.

Family ACRIDIDAE

Melanoplus sanguinipes (Fabricius)
Adults: 20♂ 20♀, 11-15 September 1967.
Nymphs: Numerous, 1-8 July 1967.
Range: A wide-ranging species in Canada, United States, and Alaska.
The species is migratory at times; extensive flights have been reported by Corkins (1922: 1-4) who observed swarms from an airplane at altitudes of 500-800 feet with a few individuals at 1,650 feet.

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AMPHIPOD AND ISOPOD CRUSTACEANS

By E. L. BOUSFIELD

During recent faunistic surveys of Sable Island, several lots of amphipod and isopod crustaceans were collected in terrestrial and shallow-water habitats by Dr. A. H. Clarke, Jr., National Museum of Natural Sciences, and by Mr. J. E. H. Martin, Entomology Research Institute, Ottawa. As these collections had been made coincidental to more thorough searches for molluscs and insects, respectively, only a small fraction of the total peracaridan crustacean fauna of the island, particularly of sand-burrowing and infaunal types, is probably represented here. Although all species recorded in this short list range more or less widely in coastal regions of eastern Canada, all records are apparently new to the island, and a few are of zoogeographical significance.

The marine amphipod *Gammarus annulatus* of southern coastal affinities is authentically recorded for the first time from Canada. The presence of the freshwater amphipod *Crangonyx richmondensis richmondensis* in sand dune ponds tends to support previous views (e.g., Bousfield 1962, 1967) that some elements of the Sable Island fauna are remnants of populations widely distributed over an island archipelago that existed in offshore regions of Nova Scotia and southern Newfoundland during glacial and immediate postglacial (to Hypsithermal) times, but that have since been almost completely obliterated by changing sea levels and marine erosion. The terrestrial oniscoidean isopods were undoubtedly introduced by human agency from Europe (*see* Palmen 1951) but the semi-terrestrial talitrid amphipods are marine dispersed and are American endemics.

LISTS OF SPECIES

AMPHIPODA GAMMARIDEA

Family GAMMARIDAE

1. *Gammarus oceanicus* Segerstrale
   Wallace Lake, 15 June 1967, JEHM coll. – 1 ♀ (br. II), 3 subadult ♀♀. A common intertidal and shallow-water euryhaline and eurytopic species of the North Atlantic region, more common along rocky and fucoid shores than on sand.

2. *Gammarus annulatus* Smith
   Wallace Lake, 15 July 1967, 16 August 1967, JEHM coll. – about 60 specimens, mostly ovig. ♀♀ but including subadult males, all with well-developed characters diagnostic of this species.

   Pond B, 14 July 1967, JEHM coll. – 1 ♂, 9 ♀♀ ovig.

   A pelagic and epibenthic species of sandy costal marine areas of New England, from Long Island Sound north to New Hampshire (Bousfield, in prep.). Previous records of this species from Canada are referable to the closely related inshore and estuarine species *Gammarus lawrencianus* Bousfield.

3. *Crangonyx richmondensis richmondensis* Ellis

Sta. 845, sand dune pond ¼ mi. S. of Meteorol. Stn. (hardness 45 ppm) 8 June 1966, AHC coll. – 1 ♀ ovig., 9 juv.

Freshwater pond, 15 July 1967, JEHM coll. – 1 ♀ (ovig.) 2 ♀♀ (br. I and II), 7 juv.

The nominate subspecies is known from American Atlantic drainages from Georgia north to Nova Scotia and Newfoundland (Bousfield 1958*a*). Previous records are from acidic or humic permanent ponds and outflows, mainly in winter-mild igneous-rock areas. The animals live close to shore, in shallow water, under debris and among roots of aquatic vegetation.

This subspecies complex has a surprisingly wide distribution in coastal areas of North America but is virtually absent from the continental interior (Mississippi and Hudson Bay drainages). However, the very disjunct nature of this distribution and the relatively restricted ecological preference and physiological tolerance of the component subspecies suggest that natural dispersal is accomplished primarily by migration through headwater bogs of adjacent and (or) interconnecting watersheds. Its presence on Sable Island, therefore, is strongly suggestive of former land connections, or near connections, with mainland Nova Scotia, from which it has been increasingly isolated by postglacial submergence and erosion of surrounding archipelagos (*see* Bousfield 1962, 1967).

Family HYALELLIDAE

4. *Hyalella azteca* Saussure

Sta. 845, June 1966, AHC coll. – about 400 specimens, in 2 lots.

Sta. 848, Lily pond near West Light (hardness 10 ppm) 8 June 1966, AHC coll. – about 200 specimens (incl. ♂♂ and ♀♀ ovig.).

Freshwater pond, 7 July 1967, JEHM coll. – 35 specimens.

Freshwater pond, 15 July 1967, JEHM coll. – 13 specimens, mostly ♀♀ ovig.

An extremely hardy and eurytopic freshwater species, widely distributed in North America south of the tree line. Its occurrence on all coastal islands having bodies of permanent fresh water is very probably attributable to wind dispersal. The present material has two dorsal pleosomal spines or mucronations.

Family TALITRIDAE

5 *Talorchestia longicornis* Say

Sta. 841, North Beach near West Light. 7 June 1966, AHC pan trap coll. – 7 ♂♂, 9 ♀♀, 50 imm.

Sta. 851A South Beach, opp. West Light landward side of drift line 150 ft. from water. 13 June 1966, AHC pan trap coll. – 3 ♂♂, 1 ♀, 5 imm.

Sta. 851B South Beach, landward side of drift line., 13 June 1966 AHC pan trap coll. – 10 ♂♂, 3 ♀♀ subad., 9 imm.

Sta. 851C South Beach – 22 ♂♂, 4 ♀♀, 18 imm.

Shore, 1 July 1967, JEHM coll. – 3 ♂♂, 3 subadult ♀♀.

Shore, 14 July 1967, JEHM coll. – 8 ♂♂, 11 ♀♀, 3 subadult specimens.

This semi-terrestrial species was also collected at Lawrencetown Beach, mainland Nova Scotia, along with *Orchestia platensis* Kr. on 20 July 1967 by Martin.

Talorchestia longicornis ranges from northern Florida to eastern Canada (Chaleur Bay, Long Peninsula, Burin Peninsula) (Bousfield 1958*b*, in prep.). It occurs more frequently than does *T. megalophthalma* on protected and estuarine sandy beaches, on steeper slopes, and farther from shore on the dunes.

6. *Talorchestia megalophthalma* Bate
   Sta. 841, North Beach, 7 June 1966, AHC pan trap coll. – 16 ♂♂, 4 ♀♀.

   Sta. 851B, South Beach, 13 June 1966, AHC pan trap coll. – 1 ♂.

   Sta. 851C, South Beach drift line. 13 June 1966, AHC pan trap coll. –9 ♂♂, 2 ♀♀.

   No specimens were collected in 1967.

This species occurs more abundantly on open, flat surf-pounded beaches, closer to the water's edge, and is more northerly in distribution, ranging from Georgia to the north shore of the Gulf of St. Lawrence (Bousfield 1958*b*).

Family CALLIOPIIDAE

7. *Calliopius laeviusculus* Kr.
   Wallace Lake, 15 July 1967, JEHM coll. –3 ♂♂, 1♀ ovig. A very common pelagic and epibenthic coastal marine species; amphi-Atlantic – in North America south to the Middle Atlantic States.

ISOPODA VALVIFERA

Family IDOTEIDAE

1. *Chiridotea caeca* (Say)
   Wallace Lake, 15 July 1967, JEHM coll. – 20 specimens, mostly ♂♂, a few ♀♀.

   Ibid. 16 August 1967 – about 30 specimens, mostly ♀♀.

   A species of sandy beaches, Florida north to Cape Breton Island. Common on open Atlantic beaches of mainland Nova Scotia, burrowing in the intertidal sands (Bousfield 1956).

ISOPODA ONISCOIDEA

Family ONISCIDAE

1. *Oniscus asellus* L.
   Sable Island, Gen. coll., terrestrial. AHC., June 1966 – 2 adults specimens. A European species, fairly widely introduced in North America, but previously recorded in eastern Canada only from ice-free, winter-mild coastal localities of Nova Scotia and Newfoundland (Palmen 1951; Bousfield 1962).

2. *Porcellio scaber* Latr.
   West Light, 13 June 1966, AHC pan trap coll. – 1 ♂, 1 imm.

   Sable Island, 17 July 1967, JEHM – about 100 specimens in 3 lots.

A hardy, very eurytopic European species, widely distributed in North America through human agency. Common in mainland Nova Scotia and Newfoundland, able to survive away from human habitation (Palmen 1951).

3. *Porcellio* sp. (*dilatatus* Brandt?)
   Sable Island, June 1966, AHC gen. coll. – 1 ♀.

4. *Trachaeoniscus (Trachelipus) rathkei* (Brandt)
   Sta. 844, near West Light, in fields, under boards, 7 June 1966, AHC coll. – 2♀♀ ovig.

   Sable Island, June 1966, AHC gen. coll. (terr.) – 25 adult specimens.

   Sable Island, 17 July 1967, JEHM – about 50 specimens in 3 lots (with *Porcellio*).

A very hardy European species with distribution in North America similar to that of *P. scaber.* Although common in mainland Nova Scotia, it is rare in Newfoundland. It is expected to survive climatic conditions of the Newfoundland region and thus probably spread further (Palmen 1951).

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THE FRESH AND BRACKISH WATER FISHES

By D. E. McALLISTER

INTRODUCTION

This paper reports three species of fishes from Sable Island, a small, low, sandy isolated island 100 miles east of mainland Nova Scotia on the Atlantic coast of Canada. The author is unaware of any previous publications on fishes of Sable Island.

The island is a crescent-shaped sand shoal, 21 miles long and up to 1 mile wide, lying near the edge of the continental shelf. The strong surf pounding the shores prevents collecting in the sea, although one egg case of the small skate *Raja erinacea* Mitchill 1825 was collected from the thousands found washed up about 0 to ½ mile east of the West Light on the North Beach, 7 June 1966. Collections were made, however, in some of the small and moderately sized ponds found on the island. The details on the collection sites are presented in Table I.

METHODS

Counts and measurements of paired structures were made on the left side. The last two rays of the dorsal and anal fins were counted as one in the Cyprinodontidae and separately in the Gasterosteidae. The specimens are catalogued in the fish collection of the National Museum of Natural Sciences, National Museums of Canada, Ottawa. The catalogue numbers are given in the table and in the species accounts.

Family CYPRINODONTIDAE

Fundululus heteroclitus heteroclitus (Linnaeus, 1766) mummichug
choquemort

Collections: NMC66-219(3); NMC66-216(27); NMC67-509-A(15). Standard lengths 21.3 to 63.8 mm.

Meristic characters: D 12-13, x=12.3; A 10-12, x=10.9; P 18-20, x=18.6; scales above lateral line 6-7, x=6.2; lateral line scales 36-40, x=38.1; G.R. 1-2 + 6-8=8-10, x total number=8.5.

Proportions: Body depth comprised 3.8-5.1, x=4.68 and caudal peduncle depth 7.4-9.5,x=8.60, of standard length. Caudal peduncle depth comprised 2.1-4.0, x=2.96, in distance from dorsal insertion to midlateral base of caudal fin. The dorsal fin index was (3.6)4.2-21.8, being the predorsal length minus the postdorsal length (mean not given, since this factor varied so greatly with size).

Except for two specimens, most (being females or young) have long thin vertical bars on the sides; the two exceptions have thicker bars, as though they were formed by the union of two ordinary bars. A black spot is found just in front of the dorsal fin. The fins are without spots. The peritoneum is dusky or black.

TABLE I

Data on Sable Island collections

	Collection data and no. specimens of each species						
National Museum Collection Number	NMC66-124	NMC66-124-A	NMC66-216	NMC66-219	NMC67-508	NMC67-509	NMC67-509-A
Place	'Lily Pond' near West Light	'Lily Pond' near West Light	Pond near West Light	Pond ¼ mile south of Meteorological Station	West end of Sable Island	Wallace Lake	West end of Pond B near Wallace Lake
Salinity	0.15‰	0.15‰	probably brackish	0.15‰	–	4.29‰	–
Ecology	2-2½ feet deep. Mud, sand, and thick vegetation. Pond of 1 acre	2-2½ feet deep. Mud, sand, and thick vegetation. Pond of 1 acre	Marsh grass, shallow pond 100-150 feet in diameter	Shallow flats of mud and marsh grass. Pond of 4 acres	Shallow marsh grass areas of pond.	–	–
Field No.	848	848	843	845	–	–	–
Collector	A. H. Clarke	A. H. Clarke	A. H. Clarke	A. H. Clarke	H. Howden	J. E. H. Martin	J. E. H. Martin
Date	9 June 1966	10 June 1966	7 June 1966	8 June 1966	11 July 1967	15 July 1967 16 Aug. 1967	Summer 1967
Fundulus heteroclitus	0	0	27	3	0	0	15
Pungitius pungitius	2	28	2	0	3	0	0
Apeltes quadracus	0	0	0	0	0	5	0

The specimens agree in most characters with *Fundulus heteroclitus*, but in one character they tend toward *Fundulus diaphanus*. Differential characters are reported by Hubbs *et al.* (1943), Brown (1957), and Scott and Crossman (1964). The specimens agree with *heteroclitus* in the low number of dorsal rays, the high gill raker count, the dark instead of lightly specked peritoneum, and the short snout. In the lateral line scale count, the dorsal fin index (of Scott and Crossman (1964)), and the body depth, the specimens are intermediate, although tending towards *heteroclitus*. The caudal peduncle depth is also intermediate, but tends towards *diaphanus*. Thus four characters are typical of *heteroclitus*. Four other characters are intermediate, three being closest to *heteroclitus* and one to *diaphanus*. The differences from typical *heteroclitus* may have resulted from past hybridization with *diaphanus*; a hybrid between the two species has been reported by Hubbs *et al.* (1943). Recent hybridization would appear unlikely, however, since *F. diaphanus* is a freshwater species that only occasionally penetrates brackish water. The differences may also be due to population divergence. The latter would not be unexpected, as the Sable Island populations are about 100 miles distant from the closest mainland populations in Nova Scotia, and as Bigelow and Schroeder (1953: 163) report "So closely, indeed, do they hug the shore that a line drawn 100 yards out from land would probably inclose practically all the mummichugs in the Gulf of Maine." Brown (1957), in a review of the genus, declined to recognize a northern (continental) subspecies, considering the diagnostic characters to be clinal, and added that a detailed study of variation in this species was needed. Taxonomic recognition of Sable Island populations would seem premature until such a variational study is undertaken.

Family GASTEROSTEIDAE

Pungitius pungitius (Linnaeus, 1758) — ninespine stickleback
épinoche à neuf épines

Collections: NMC66-124(2); NMC66-216(2); NMC66-124-A(28) NMC66-508(3). Standard lengths 9.4 to 41.5 mm.

Meristic characters: Dorsal spines VIII-XI, $\bar{x}$=9.5; dorsal rays 9-12, $\bar{x}$=11.1; A I 9-11, $\bar{x}$=I9.7; V I1, $\bar{x}$ I1.0; P 10, $\bar{x}$=10.0; lateral plates 1-4, $\bar{x}$=1.9; G.R. 1-3 + 9-11 = 11-13, $\bar{x}$ total number 11.5.

Proportions: Pectoral fin length / pelvic spine length 1.3-2.0, $\bar{x}$=1.61.

McPhail (1963) described two forms of ninespine stickleback in North America, one coastal in distribution, probably originating during glaciation in the Bering Sea area, the other inland, probably originating in freshwaters of the Mississippi basin. In the present specimens, two characters, plate number and dorsal spine number, are intermediate but tend towards the freshwater form; the other two characters, pectoral spine length and gill raker number, are definitely characteristic of the coastal form. The weight of the characters, including the least variable one, gill raker number, is thus towards the coastal Bering form. This is indeed what would be expected if Sable Island was populated from the Atlantic provinces and the New England states, which are inhabited by the coastal Bering form.

Apeltes quadracus (Mitchill, 1815) fourspine stickleback
épinoche à quatre épines

Collections: NMC67-509(5). Standard lengths 19.6 to 45.0 mm.

Meristic characters: D II-III, I10-13, $\bar{x}$=2.8, I11.6; A 19, $\bar{x}$=9.0; V I2; P 11, $\bar{x}$=11.0; G.R. 7-9, $\bar{x}$=7.5.

Proportions: Length of the first dorsal spine comprised 9.1-15.4, $\bar{x}$=11.4, and pelvic spine length comprised 6.9-9.1, $\bar{x}$=8.1, of standard length.

Krueger (1961) reports that freshwater populations of fourspine sticklebacks have strong modes of 5 dorsal spines (all spines counted) whereas those of high salinities show strong modes of 4 spines. Although the present sample is not adequate, the few specimens present have counts of 3 or 4, which are typical of the marine populations. This might be expected if Sable Island was populated from coastal populations.

DISCUSSION

The question naturally arises as to how these fishes came to Sable Island, which is 100 miles from the nearest populations on the mainland. As the three species are euryhaline, salt water would not appear to constitute a barrier. Their ability to cross narrow ocean straits is demonstrated by their presence on Newfoundland (Scott and Crossman 1964), the Magdalens, and on Anticosti Island (Cox 1921; Leim and Scott 1966; McPhail 1963; Schmitt 1904), although *Apeltes quadracus* has not yet been reported from the latter island. These islands are not, however, more than 50 miles from the closest populations of the species. The shore-hugging distribution of *Fundulus heteroclitus* has already been mentioned. But *Fundulus heteroclitus* has managed to populate Bermuda, some 600 miles off eastern United States, where it forms an endemic subspecies *F. h. bermudae* Günther (Brown 1957). These facts show that despite their shore-hugging habit they are still capable of reaching offshore islands. Bigelow and Schroeder (1953: 308) note of *Pungitius pungitius,* "Since the range of the nine-spined stickleback hardly touches the open waters of our Gulf . . ." and of *Apeltes quadracus* (p. 312) "But it is so much more closely restricted to estuarine situations than is its three-spined relative (p. 310) that we have never taken it in our tow nets nor do we find a single record of it in the open sea."

Yet despite these habits, since they have populated an island 50 miles away, it is not difficult to conceive their reaching an island 100 miles away. Even if the adults are shore-hugging in habit, it is within the realm of possibility that either adults or young were carried offshore by unusual storms or currents. It is possible that colonization might not have been from Nova Scotia, although this provides the closest landmass, but from further south with the immigrants being carried by the Gulf Stream.

Another explanation is possible. Clarke (1967) and Clarke *et al.* (1967) suggest that Sable Island was much wider during the Hypsithermal period and that portions of the continental shelf between the mainland and Sable Island may also have been above sea level during that period and later. Larger size would increase the probability of drifting specimens meeting the island, and

intermediate islands would provide stepping stones to Sable Island. There is presently insufficient data to determine which hypothesis is most favourable.

The forms of *Fundulus heteroclitus, Pungitius pungitius,* and *Apeltes quadracus* found on the island are morphologically the saltwater forms. This would support invasion of the island by coastal forms from the mainland, perhaps by intermediary islands. No direct connection with the continent is necessary to explain the presence of these species on the island.

SUMMARY

Fundulus heteroclitus, Pungitius pungitius, and *Apeltes quadracus* are reported for the first time from Sable Island, 100 miles off mainland Nova Scotia, in fresh and slightly brackish ponds. The presence of these species on the island does not call for a past land connection with the mainland, as they are capable of crossing stretches of salt water to islands.

ACKNOWLEDGMENTS

The author is grateful to Dr. A. H. Clarke, Jr. Dr. H. F. Howden, and J. E. H. Martin, who kindly collected fish specimens in the course of other studies.

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APPENDIX I

SABLE ISLAND NOCTUOIDEA

E. W. ROCKBURNE and D. F. HARDWICK*

	No. of specimens
ARCTIIDAE	
Diacrisia virginica Fabr.	29
NOCTUIDAE	
Argrotis volubilis Harv.	128
Aletia oxygala Grt.	44
***Amathes c-nigrum Linn.*	84
Amathes smithi Snell.	31
Amphipoea interoceanica Sm.	3
Apamea finitima Gn.	72
Apamea inordinata Morr.	2
Autographa precationis Gn.	1
Euxoa detersa Wlk.	166
Euxoa messori Harr.	1
Faronta diffusa Wlk.	4
Lacinipolia lorea Gn.	74
Nephelodes emmedonia Cram.	29
**Ochropleura plecta* L.	113
Oligia bridghami G. & R.	1
Ommatostola lintneri Grt.	10
Paipema sp. probably *nelita* Stkr.	2
**Perodroma saucia* Hbn.	1
**Pseudaletia unipuncta* Haw.	8
Polia pulverulenta Sm.	1
Rhynchagrotis cupida Grt.	4
Spaelotis clandestina Harr.	1

*Entomology Research Institute, Canada Department of Agriculture, Ottawa.

**Holarctic species, presumed native to North America; remainder endemic to North America.

APPENDIX II

THE FRESHWATER AND TERRESTRIAL ANNELIDA

By G. E. GATES and J. E. MOORE

During the Sable Island faunistic survey work of 1966, three species of leeches (Hirudinea) and two species of earthworms (Oligochaeta) were obtained. The former have been identified by Dr. J.E. Moore, Edmonton, Alberta, and the latter by Dr. G. E. Gates, Bangor, Maine. All three species of leeches are widely distributed and North American endemic, whereas the two oligochaete worms are both of European origin and were probably introduced by human agency. All records appear to be new to Sable Island.

SPECIES LIST

HIRUDINEA

The following material was obtained from Lily Pond, near West Light, Station 848, 10 June 1966, A.H. Clarke coll.

Haemopis marmorate (Say) – 1 adult specimen.
Helobdella stagnalis (L.) – 11 immature specimens (in 2 lots).
Erpobdella punctata (Leidy) – 1 adult specimen.

OLIGOCHAETA

The following material was obtained during general terrestrial collecting by A.H. Clarke, June 1966.

Lumbricus rubellus Hoffmeister 1843 – several specimens (NMC 1159, 1160).
Dendrobaena sp. (poss. *rubida* Sevigny) – 2 small specimens (NMC 1161).